Gamma-ray emission from misaligned AGN

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Radio-loud Misaligned AGN (MAGN)

MAGN: AGN with jet not aligned along the line-of-sight (l.o.s.)
  Doppler boosting negligible
  Radio galaxies (RG) and steep-spectrum radio quasars (SSRQs)
Abundant radio data: total (including lobes) and central region (core)

Radio galaxies: classified by Fanaroff&Riley (1974)
  FRI edge-darkened, less powerful, Bl Lacs parent
  FRII edge-brightened, more powerful, FSRQs parent

Fermi-LAT observed 15 MAGN between 0.1-100 GeV (Fermi-LAT ApJ 720, 2010)
Some of them are variable.

Could these objects contribute
in a significant amount
to the diffuse extra-galactic background (EGB)?

Fermi-LAT MAGNs: main radio and gamma properties

MAGN(FRI,FRII)	z	b°	α^{C}_{5GHz} (α^{tot}_{5GHz})	S^{C}_{5GHz} [Jy] (S^{tot}_{5GHz}) [Jy])	Γ	F_{γ} [10^{-9}ph/cm^2/s]
3C 78(I)	0.02865	-44.6	0 (0.64 [2])	0.964 ± 17% [2] (3.40 ± 0.11[3])	1.95 ± 0.14	4.7 ± 1.8
3C 274(I)	0.0038	74.5	0 (0.79 [9])	3.0971 ± 0.0300[8] (71.566 ± 0.993 [10])	2.17 ± 0.07	25.8 ± 3.5
Cen A(I)	0.0009	19.4	0.30[11] (0.70[11])	6.984 ± 0.210[12] (62.837 ± 0.099 [13])	2.76 ± 0.05	175 ± 10
NGC 6251(I)	0.02471	31.2	0(0.72[10])	0.38 ± 0.04 [14] (0.510 ± 0.050 [14])	2.20 ± 0.07	18.2 ± 2.6
Cen B(I)	0.01292	1.68	0 (0.13[17])	2.730[16] (6.58 ± 1.04[17])	2.33 ± 0.12	39.3 ± 11.4
For A(I)	0.005871	-56.7	0.50[18](0.52 [2])	0.051[18] (72[2])	2.16 ± 0.15	7.7 ± 2.4
3C 120(I)	0.03301	-27.4	0 (0.44[19])	3.458 ± 0.588 [2] (8.60 ± 1.46[2])	2.71 ± 0.35	29 ± 17
* PKS0625-35(I)	0.05459	-20.0	0 (0.65 [4])	0.600 ± 0.030 [4] (2.25 ± 0.09 [5])	1.93 ± 0.09	12.9 ± 2.6
Pictor A(II)	0.03506	-34.6	0 (1.07 [2])	1.15 ± 0.05[20] (15.45 ± 0.47[5])	2.93 ± 0.03	21.9 ± 3.6
3C 111(II)	0.04850	-8.61	-0.20 [1] (0.73[6])	1.14[21] (6.637 ± 0.996[19])	2.54 ± 0.19	40 ± 8
* 3C 207(II)	0.6808	30.1	0 (0.90 [6])	0.5391 ± 0.0030[7] (1.35 ± 0.04 [5])	2.36 ± 0.11	17.3 ± 3.3
* 3C 380(II)	0.692	23.5	0 (0.71[10])	5.073 ± 0.105 [15] (7.45 ± 0.37 [5])	2.34 ± 0.07	30.3 ± 3.7
IC 310(I)	0.01894	-13.7	faint(0.75[24])	faint (0.258 ± 0.031[25])	2.10 ± 0.19	11.1 ± 6.2
3C 84(I)	0.01756	-13.2	(0.78[6])	high variability	2.00 ± 0.02	175 ± 8
PKS 0943-76(II)	0.270	-17.2	faint	faint(0.757[23])	2.44 ± 0.14	19.5 ± 5.1

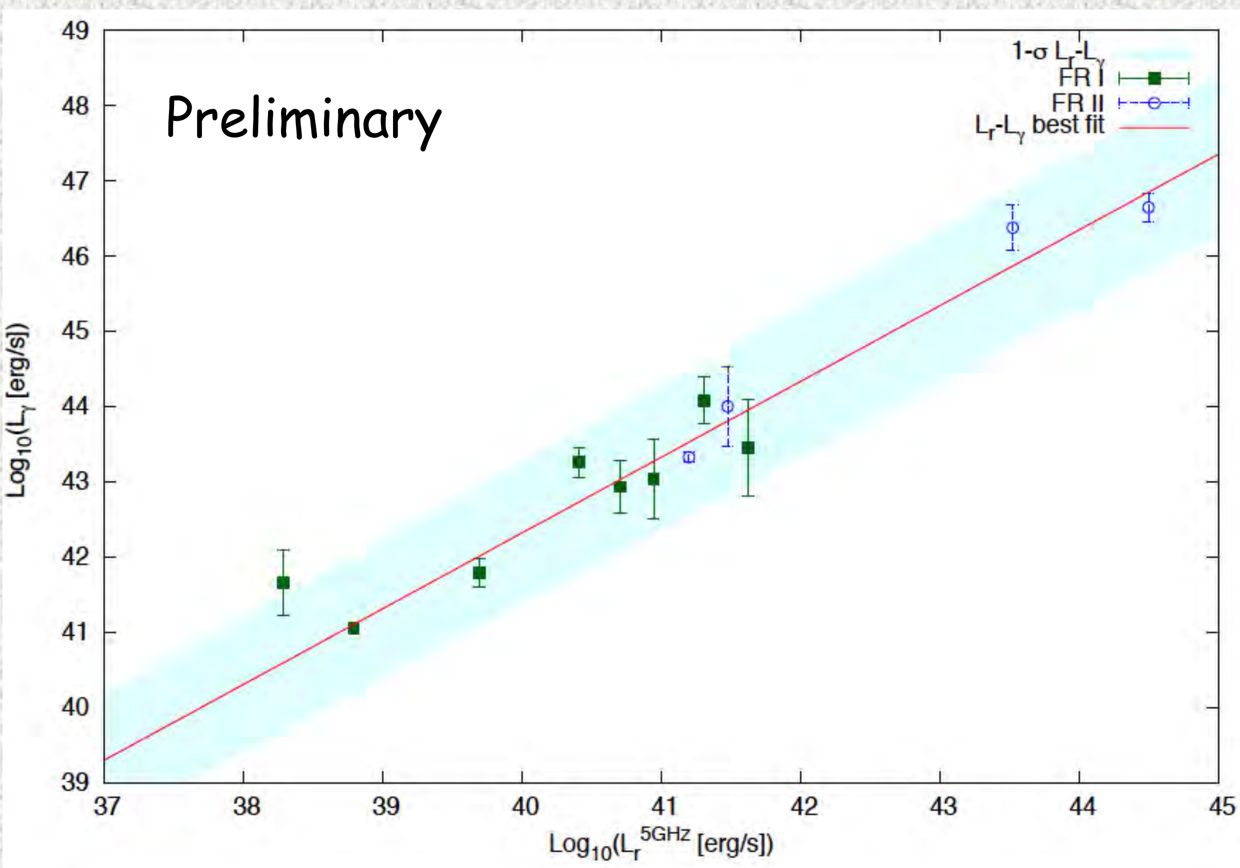
Radio data taken at 5 GHz an near in time to Fermi-LAT

* Are not firmly FRI / FRII RG

Gamma-ray luminosity function

Correlation between radio core emission at 5 GHz and gamma > 100 MeV

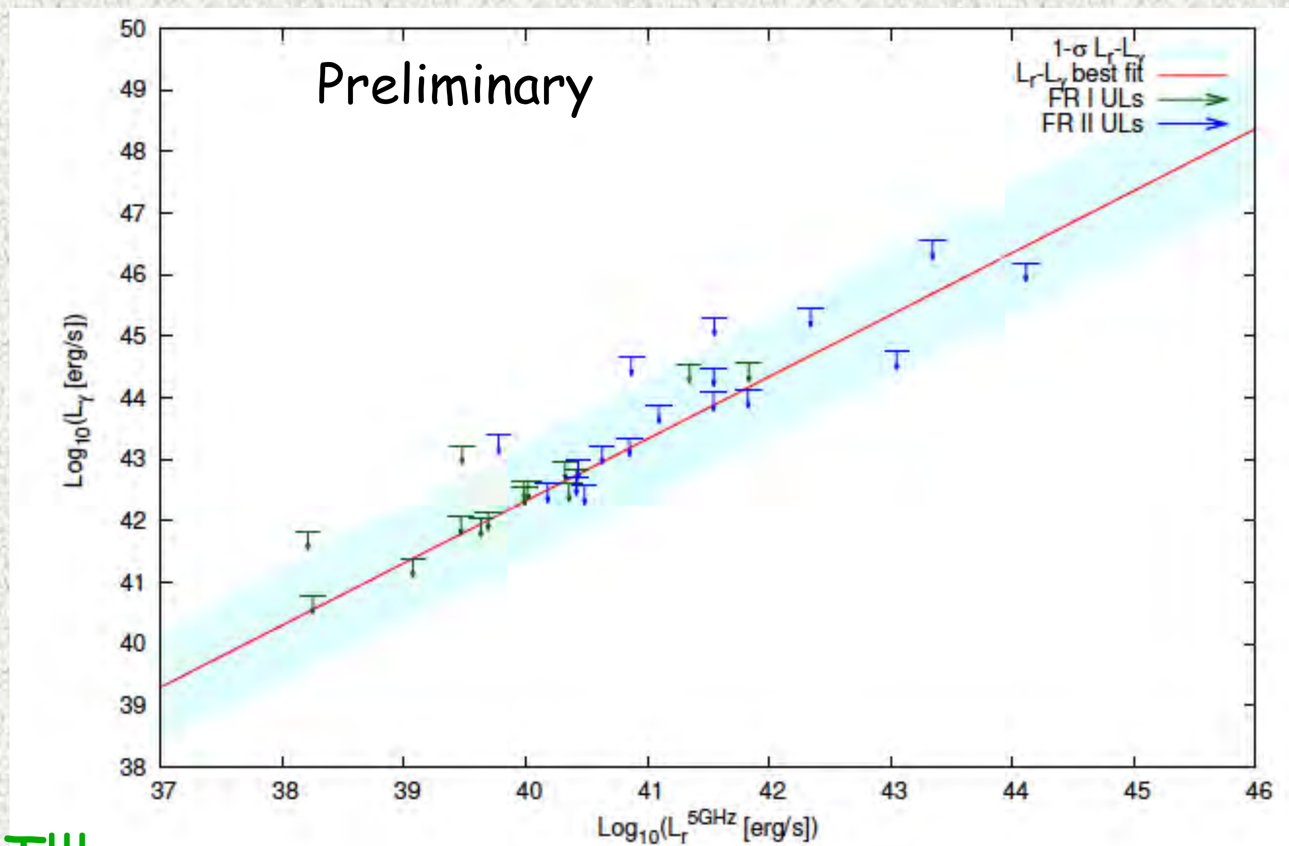
$$\log_{10}(L_\gamma) = 2.01 \pm 0.96 + (1.008 \pm 0.024)\log_{10}(L_{r,core}^{5GHz})$$



N. B. Similar results if we exclude: 3C380, 3C207; PKS0625-350

Testing L_γ-L_r correlation: upper limits from undetected FRI&FRII

We derive upper limits for FRI (Ghisellini+ 2005) and FRII (Kataoka+2011) having strong radio core fluxes



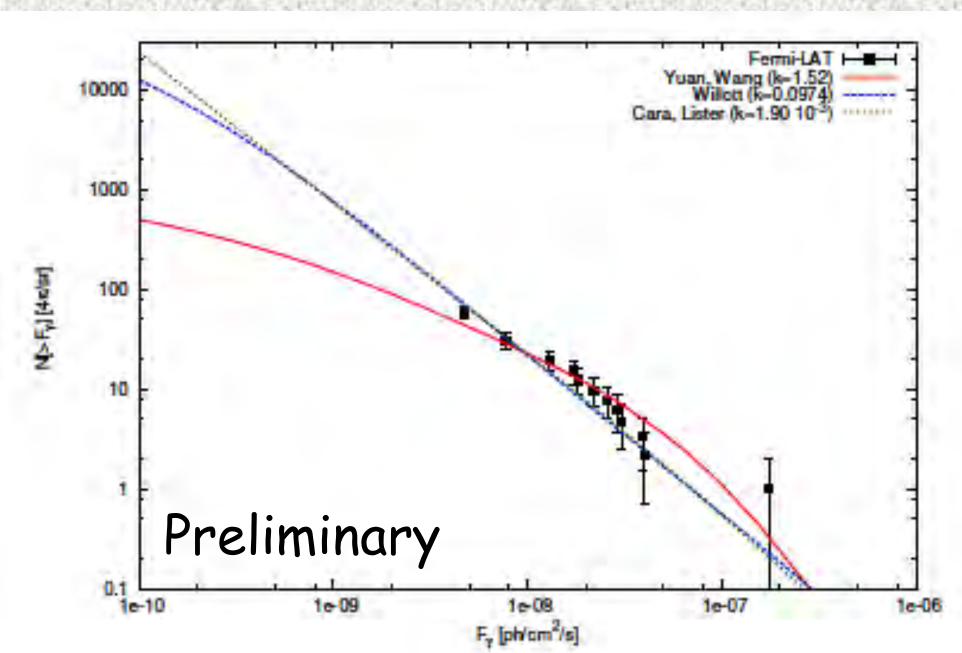
GREAT!!!

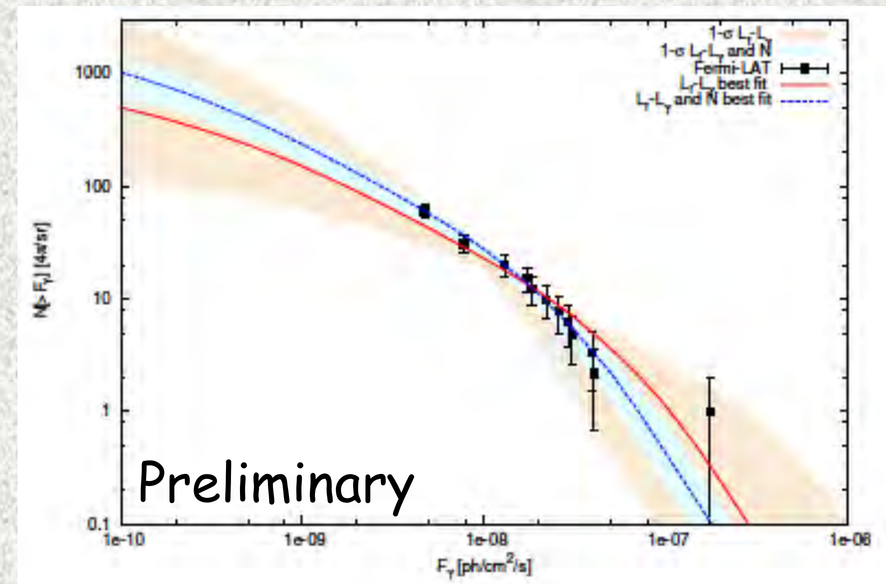
they do not violate the correlation → It looks physical

Constraints from logN-logS

Let's assume: $$\rho_\gamma(L_\gamma, z) = k\, \rho_r(L_r, z) \frac{d \log_{10} L_r}{d \log_{10} L_\gamma}$$

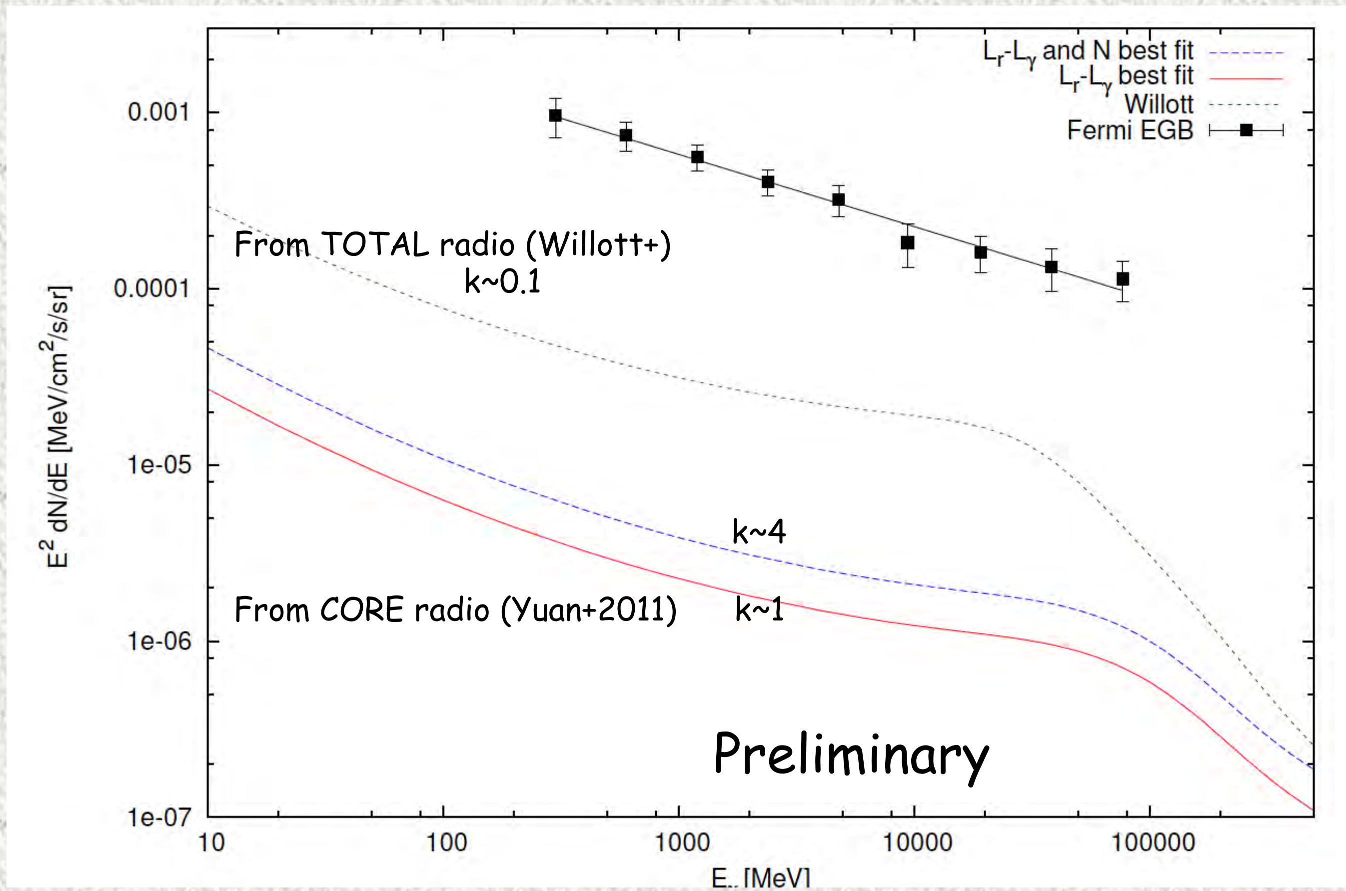
$$N_{th}(> F_\gamma) = 4\pi \int_{\Gamma_{max}}^{\Gamma_{min}} \frac{dN}{d\Gamma} d\Gamma \int_0^{z_{max}} \frac{d^2V}{dz d\Omega} \int_{L_{\gamma,min}}^{\infty} \frac{dL_\gamma}{L_\gamma \ln(10)} \rho_\gamma(L_\gamma, z, \Gamma)$$





1. **Core-Luminosity function** (Yuan&Wang ApJ 2012) **predicts k~1!!**
2. **Fermi-LAT N-count can be added to the fit to reduce uncertainties**

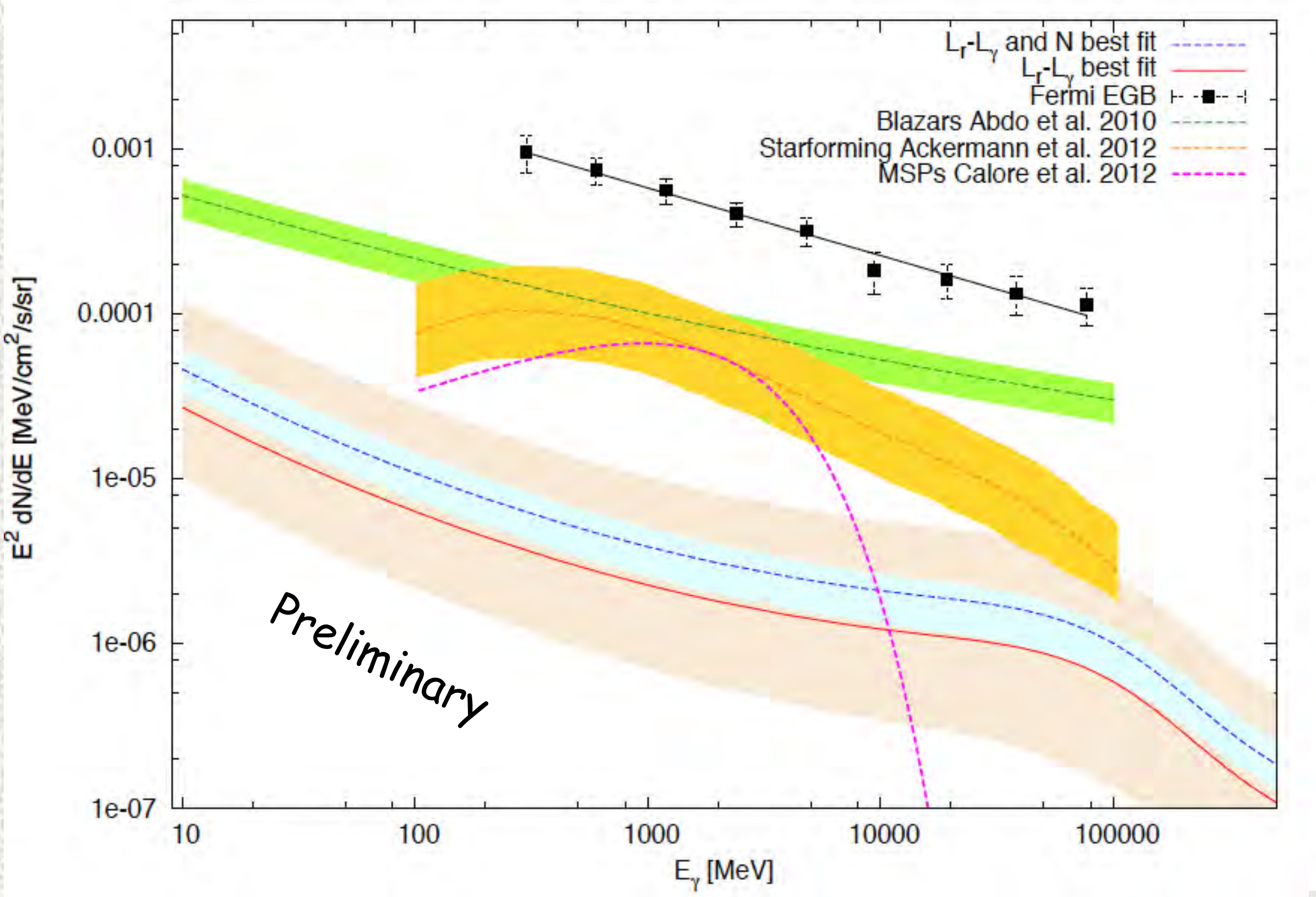
I- Diffuse γ-ray flux from unresolved MAGN



Diffuse flux VERY LOW when obtained from correlating with radio emission from the central engine region, ~ 1% of EGB data

Increases by ~10 if from correlation with total radio emission

II- Diffuse γ-ray flux from unresolved MAGN



Uncertainty due to L_γ-L_r correlation ~ 10

Uncertainty due to L_γ-L_r correlation & logN-logS ~2-3

Conclusions

New calculation of diffuse gamma-ray emission from MAGNs

•Strong **correlation** between radio core emission at 5 GHz and gamma-ray data for Fermi-LAT detected MAGN

•Correlation strengthened by **upper limits** on radio loud FRI,II undetected by Fermi-LAT

• Luminosity agrees with data on **N-count** without need of rescaling

• The diffuse emission from MAGN is **very low**, 1% Fermi-LAT of measured EGB

•**Uncertainties** range between a factor of 2 and 10 depending on the use of the observed N-count.

BACKUP SLIDES

Upper limits from FRI & FRII

Preliminary

MAGN(FRI,FRII)	z	S^{C}_{5GHz} [Jy]	$TS_{unbinned}$	$F^{UL}_{unbinned}$	TS_{binned}	F^{UL}_{binned}
3C 18 (II)	0.188	0.083[1]	< 1	2.69	2.57	6.05
B3 0309+411B (II)	0.134	0.320[2]	-	-	< 1	5.78
3C 215 (II)	0.412	0.0164[3]	0.084	3.06	4.14	6.01
3C 227 (II)	0.086	0.032[1]	< 1	0.84	< 1	1.08
3C 303 (II)	0.141	0.150[3]	< 1	2.85	3.30	4.60
3C 382 (II)	0.058	0.188[3]	< 1	4.06	1.16	5.88
3C 390.3 (II)	0.056	0.120[4]	< 1	1.75	2.97	4.71
3C 411(II)	0.467	0.078[5]	-	-	< 1	6.09
4C 74.26 (II)	0.104	0.100[6]	1.10	5.43	<1	5.75
PKS 2153-69 (II)	0.028	0.300[7]	4.18	6.56	<1	6.18
3C 445 (II)	0.056	0.086[1]	<1	0.74	<1	1.03
3C 465 (I)	0.029	0.270[3]	-	-	< 1	0.51
3C 346 (I)	0.162	0.220[3]	4.48	6.37	10.74	10.2
3C 264 (I)	0.021	0.200[3]	8.99	5.61	13.97	7.52
3C 66B (I)	0.022	0.182[3]	-	-	< 1	8.3
3C 272.1(I)	0.003	0.180[3]	[illegible]	(5.62)	5.26	6.74
3C 338 (I)	0.030	[illegible]	-	-	< 1	4.56
3C 293 (I)	0.045	[illegible]	< 1	1.52	<1	1.85
3C 29 (I)	[illegible]	0.093[3]	< 1	1.48	<1	4.11
3C 31(I)	[illegible]	0.092[3]	-	-	< 1	3.92
3C 310 (I)	0.054	0.080[3]	< 1	1.16	¡1	2.13
[illegible] (I)	0.024	0.077[3]	< 1	1.51	<1	2.30
3C 449 (I)	0.017	0.037[3]	< 1	0.49	<1	0.80
3C 288 (I)	0.246	0.030[3]	< 1	1.52	1.63	3.68
3C 83.1B (I)	0.026	0.040[3]	9.9	(19.7)	16.50	23.2
3C 438 (II)	0.290	0.0071[3]	< 1	(1.01)	¡1	3.25
3C 386 (I)	0.018	0.120[3]			< 1	3.17
3C 433 (II)	0.102	0.005[3]			< 1	1.90
3C 442A (I)	0.027	0.002[3]			<1	0.86
3C 245 (II)	1.029	0.910[3]	< 1	1.98	<1	4.01
3C 109 (II)	0.306	0.963[3]	< 1	1.36	<1	3.53
3C 212 (II)	1.049	0.150[3]	6.39	7.12	10.11	8.80
da 240 (II)	0.036	0.105[3]	< 1	1.53	<1	2.79

N-count with 9 MAGNs